

Sustainable Approach for Cloud-Based Framework Using IoT in Healthcare



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1 Introduction

During the last few years, cloud computing and IoT has become an emerging field in the industry. In earlier days it was very difficult to trace and manage the patient and its related records nowadays with the help of advanced Technologies and applications, it has become convenient easy and efficient to trace patient geography and excess records from previous databases. Due to the advancement in the technological field, the advancement in the architecture of cloud based applications has also changed the way user and client communicates with each other. This has a rapidly changed the models and the components related along with functionality, storage, exchange, manage information. Why IoT for Healthcare is becoming important with respect to time? There are various reasons for growth of the internet of things (IoT) in Healthcare. One of the main reason is the people who live in rural areas are unable to avail Health Services due to distance so in order to bring them closer to the health facilities applications are being developed for the Healthcare [1], so that they can avail health facilities quickly and can be stayed connected. This problem is not limited to rural areas, but it has rapidly increased in Metropolitan cities if anyone needs an emergency service for health related services then it is very difficult for a person to connect to a right health service which is nearest to its place. With the development of the Healthcare monitoring ecosystem system [2], the current health of a patient can be monitored and related measures can be taken.

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2 Literature Review

In 1997, Cloud computing was described by Professor Ramnath Chellappa as the current computing model where the lines of computing will be complete with commercial rationale rather than technical limits alone. Google provides cloud services as Google Cloud Platform (GCP). Google gains a powerful game in the world of cloud services. Google cloud platform was launched in the year 2008. Google cloud platform offers so many features. In this one feature is the use of managed VMs (virtual machines). Google enters in the cloud services in 2008 with the view of Google App Engine [3]. In this paper PaaS service that enabled purchaser to use Google's platform to develop and host their applications. Problems with Google App Engine were the lack of outstanding developer languages, it supported and the absence of Storage solution. Planners of Google Cloud Platform (GCP) [4] were mandatory write their functions using Python. In 2009, Google achieved more benefits after the extension of multiple services like Google compute engine and to manipulate functions like DNS and data analyst. Java is included as a supported language (Table 1).

Google Cloud Platform is available in 200+ countries across the globe. Google Cloud Platform enables a user to build, deploy, and manage Virtual Machines (VMs) to run workloads in the cloud. Google Cloud Platform offers a free tier that includes a micro instance per month for up to 12 months. It is the easiest way to run your code in the cloud. Also, it is highly available and fault-tolerant [6]. The unified object storage for live or archived data provided for Google Cloud Platform (GCP). This service is used to store and access data in GCP infrastructure. The Google Cloud Platform provides storage that can be attached to instances running in either Google Computer Engine or Google Kubernetes Engine. GCP does not have any disaster recovery service. GCP offers high performance and scalability. Also, it helps in maintaining relational MYSQL, and SQL Server databases in the cloud. GCP provides better pricing than competitors, live migration of Virtual Machines (VMs), improved performance, redundant backups. Some disadvantages Google Cloud Platform support fee is quite hefty, it has a complex pricing schema, downloading data from GCS is expensive (i.e., it's 0.12 per GB). Companies using the Google Cloud Platform are Netflix, Unilever, Kellogg's, Samsung, Spotify, HSBC, Snapchat, etc. [7] (Fig. 1).

In February 2010 Microsoft Azure was launched, and promises to deliver services as infrastructure-as-a-service and service and platform as a service [8]. Microsoft Azure cloud structure the oldest cloud service provider in the industry. It consists of following features.

- Compute
- Networking
- Storage
- Web
- Mobile
- Containers

Table 1 Summary of related work in the area of healthcare and IoT

Paper name	Authors name	Objective	Finding	Area	Method	Citation
Personal Health Care Framework for Children	Nina Sevani	<ul style="list-style-type: none"> Adolescent healthcare needs precautions and attentive attention Healthcare is combined with the finite efficiency of the child Mainly a child with unique problem, like disorder Use of holistic structure also protects the adolescent from unaware bacteria 	<ul style="list-style-type: none"> Adolescent's healthcare requires helpers, such as a pediatrician Usage of Primary Health Care's framework to control child's health that is also managed according to the health situation of the child [5] 	Health Sector	The use of a PHC's framework	[3]
e-Health networking to cater to Rural Health Care and Health Care for the Aged	D. S. Venkateswarlu, K. S. Verma, and K. S. R. A. Murthy	<ul style="list-style-type: none"> Healthcare conditions in India engineering that can decrease the amounts it is attracted on Wireless Electronic Communication Technologies (ICT) on health care 	<ul style="list-style-type: none"> Usage of elemental CDMA methodology through wireless line diagnostic method 	E-Health Networking	Telemedicine, e-health networking	[5]
Healthcare technology management applied to public primary care health	Saulo José Argenta Garcia, Rubia Alves da Luz Santos, Priscila Sousa de Avelar, Renato Zaniboni, Renato Garcia	<ul style="list-style-type: none"> The University of Bio-medical Engineering of Santa Catarina is established from the Municipal Health Secretariat Establishment of this institute is for primary health care 	<ul style="list-style-type: none"> The formation of this structure in the CS of FLN-SMS has given a major effect on the majors of healthcare in initial healthcare 	Health care technology management sector	Local Centre of Clinical Engineering	[8]

(continued)

Table 1 (continued)

Paper name	Authors name	Objective	Finding	Area	Method	Citation
Health Informatics for Low-Cost and High-Quality Health Care	Carmen C. Y. Poon, Wenbo Gu, and Y. T. Zhang, Fellow, IEEE	<ul style="list-style-type: none"> Standardization of MINDSS machines that needed an analysis, like the calibration method of cuff-less blood pressure analysis machines, is reviewed 	<ul style="list-style-type: none"> P-Health is expected as a future less amount health model that provide best health qualities 	Health sector	P-Health	[11]
Designing Interactive Health Care Systems: Bridging the Gap Between Patients and Health Care Professionals	Lisa Graham—IEEE Student Member, Mohammad Moshirpour—IEEE Student Member, Michael Smith—Senior IEEE Member, Behrouz H. Far—IEEE Member	<ul style="list-style-type: none"> As sufferers become active about their wellness and grow into techniques such as the Internet of Things (IoT) 	<ul style="list-style-type: none"> Personal Health Care System (PHCS) and e-Health can give sufferers with data about their wellness while granting them to committing extra data about their health 	Scenario-based software engineering	Personal health systems and eHealth systems	[13]
Complexity of Cyber Security Architecture for IoT Healthcare Industry: A Comparative Study	Aysha K. Alharam, and Wael El-madany	<ul style="list-style-type: none"> Currently, a huge array of Internet of Things wearable wellness functions has been advanced Secure healthcare sector from cyber-attacks attacking on Internet of Things based wellness devices 	<ul style="list-style-type: none"> This paper explained the insoluble problem of cyber security structure for the Internet of Things (IoT) based on health care 	Complexity issue of cyber security	IP core architecture	[16]
Development of Health Care System Based on Wearable Devices	Pin-Chieh Huang, Chung-Chih Lin*, Yu-Han Wang, Hisang-Jen Hsieh	<ul style="list-style-type: none"> The healthcare structure in this paper is described to consist of wearable machines and information 	<ul style="list-style-type: none"> In this study, the notification data daily provides information to their place who have a chronic disease 	Smart Health Technology	Wearing health devices	[19]

(continued)

Table 1 (continued)

Paper name	Authors name	Objective	Finding	Area	Method	Citation
Health Care in the Age of Interoperability Part 6: The Future of FHIR	Mark L. Braunstein	<ul style="list-style-type: none"> The objective of this study is to dramatic transformation in the health care informatics in huge scale because of new Health Level 7 (HL7) 	<ul style="list-style-type: none"> The main motive of the study is to introduce researchers from other sectors in the recent area of health information 	Health field	Patient care	[20]
Toward a Health Care Technology Management Knowledge Base	Jair A. Villanueva P., Fabiola M. Martínez L	<ul style="list-style-type: none"> Objective of this paper is to represent the growth of the primary level of a healthcare technology system on the knowledge base 	<ul style="list-style-type: none"> The motive and main technology is forum of advising for professionals and for those who are interested 	Development of health	Health Management	[21]
Improving IOT Based Architecture of Healthcare System	Inderpreet Singh, Deepak Kumar	<ul style="list-style-type: none"> Enhance and improve Internet of Things (IoT) based architecture 	<ul style="list-style-type: none"> It represents the dissimilar section of a medical system and the device sensor being used to set up the biological structure 	Internet of Thing (IoT)	Health framework	[23]

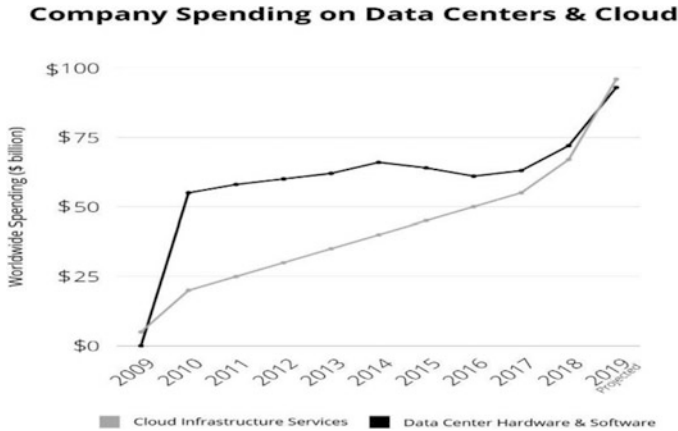


Fig. 1 Investment Cloud Infrastructure. (Source: Synergy Research Group)

- Databases
- Analytics
- AI + Machine Learning
- Internet of things
- Integration
- Identity

Microsoft Azure has a good market value since last more than 10 years, now it is present in more than 140 countries and has the second [9] highest number of customers around the globe after Amazon Web Services; it is the second best Cloud Service Provider in the market after Amazon Web Services.

Microsoft provides many services to its clients, which includes computing services, functional services, networking services, VPN services, etc., on the other hand it also helps its clients to increase or decrease VPN Service according to the usability [10]. Microsoft Azure has various clients from Netflix, Kellogg's, Samsung eBay Pixar Unilever etc. Microsoft Azure provides better development operations strong security profile, cost effective solutions, etc. Some disadvantages of Microsoft Azure are different codebase for cloud and premise, the PaaS ecosystem is not as efficient as IaaS, poor management of GUI and tools, no integrated backup. Azure has a free tier for a year with 750 h per month of Windows or Linux Virtual Machines. Azure functions allow users to build an application using the server less, simple function with a programming language of their choice. Blob Storage offers large amounts of storage and scalability. It stores the object in the tiers; depending on how often the data is being accessed. Microsoft Azure managed disk will allow you to create up to 10,000 VM disks in a subscription. Microsoft Azure is a strategy that allows site recovery by orchestrating and automating the replication process of Azure Virtual Machines (VMs) between regions. Azure eases the migration of SQL server databases without changing the user's applications [11].

Table 2 Microsoft Azure vs. Google cloud platform

Services	Microsoft Azure	Google Cloud Platform
IaaS	Virtual Machines	(GCE) Google Compute Engine
PaaS	Application Service and Cloud Services	Google App Engine
Containers	Azure Kubernetes Service (AKS)	Google Kubernetes Engine
RDBMS	SQL Database	Google Cloud SQL
Server Less Functions	Azure Functions	Google Cloud Functions
Pricing	Pre-Paid service Minute by minute	Pre-Paid service Up to (minimum 10 min)
Model	On demand Prepaid model	On-demand sustained use
Data Transfer	Azure port/Export Service	Storage Transfer Service

Google Cloud Platform (GCP) is one of the leaders among cloud API (Application Programming Interface). Microsoft Azure is the second leading cloud provider after the Google Cloud Platform. We have compared compare in-depth the features of Microsoft Azure and Google Cloud Platform deemed to provide security with a particular focus on confidentiality, integrity, and availability of data. Comparatively Google Cloud Platform gives better pricing than competitors. Azure functions allow users to build an application using the server less, simple function with a programming language of their choice [12]. The Google Cloud Platform provides unified object storage for live or archived data. Google Cloud Platform (GCP) offers high performance and scalability (Table 2).

Internet of things (IoT) is a technology to synthesize several devices on the internet and permits them to share and transfer information, data and resources among them. There are embedded sensors in all the devices we come across like mobile phones, traffic lights, and electrical appliances, etc., these sensors help them to integrate over the internet [13]. This sensor ceaselessly radiates data and helps us track them as well as knowing their proper working. IoT connects all physical devices like microphones, cameras, speakers display screens etc. This technology helps to blend their data and provide a common language to communicate with each other (Fig. 2).

In healthcare, IoT helps the hospital management system to make comprehensive patient records, test results and treatment reports [14].

Although there still are some challenges like

- Unavailability of real time data
- Insufficient smart devices

Internet of things (IoT) could be the solution of all these issues. It can provide real time data and make devices smarter so that they can provide analytics. Internet of things (IoT) [15, 16] makes devices smarter. Internet of things (IoT) empowers healthcare and improves the quality of care. In the end, it directs the un-sustainability rising cost of medical devices.

Fig. 2 Growth of Google cloud platform and Microsoft Azure 2015–2019

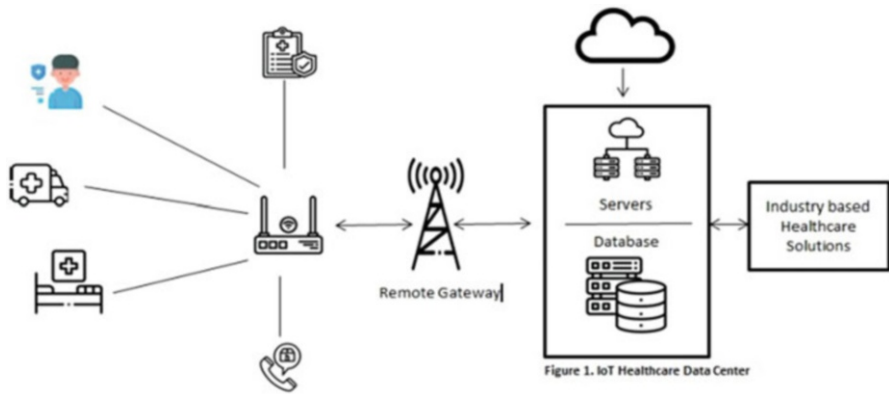
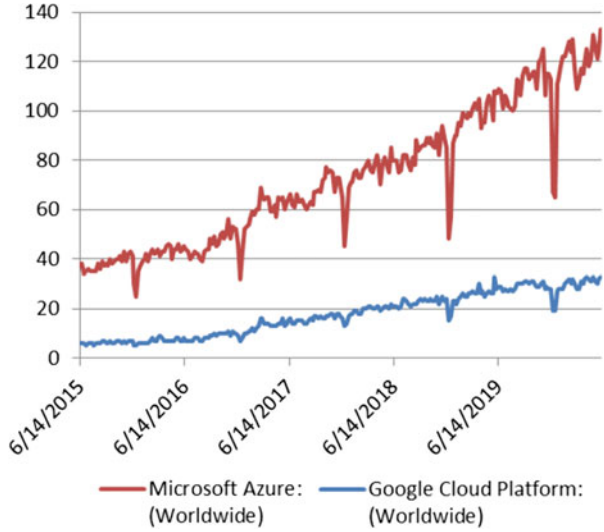


Fig. 3 Internet of things (IoT) Healthcare Architecture

3 Internet of Things (IoT) Healthcare Architecture (Fig. 3)

Google provides an API which application program interface tool for cloud healthcare. The cloud healthcare API is costing consist of various factors like (Tables 3 and 4)

- Data storage
- Network utilization
- Number of requests

Table 3 Data Storage—Plan

Storage class	0–1 GB (per GB per month)	1–1024 GB (1 TB) (per GB per month)
Structured storage	\$0.00	\$0.39
Blob storage	\$0.00	\$0.023
Storage class	0–1 GB (per GB per month)	1–1024 GB (1 TB) (per GB per month)
Structured storage	\$0.00	\$0.39
Blob storage	\$0.00	\$0.023

Source: Google

Table 4 Request Plan

Category	0–25,000 requests	25,000–1 billion requests	1 billion + requests
Standard requests	\$0.00	\$0.39	\$0.29
Complex requests	\$0.00	\$0.69	\$0.59
Multi-operation requests	\$0.00	\$0.39	\$0.29

Source: Google

4 Applications of Internet of Things (IoT) in Health Cloud

Health Tracking App These types of software help to track the health of the patient and generate quality of information which can be helpful for the doctor to take necessary steps. These types of apps can track heartbeat [17, 18], blood pressure, pulse rate diabetes, irregular breathing, fever, weight etc.

Internet of Things (IoT) for Patients Internet of things (IoT) has changed the patient's lifestyles, by keeping track of their condition [19]. Wearable devices like fitness bands and some wireless devices like blood pressure and heart rate to monitor the situation of a patient.

Internet of Things (IoT) for Nutrition Nutrition is a very important for individuals to be healthy and to live a happy life. Fooducate is nutrition app. App provide service of comparing various types of food for individual and recommends the best result among all. This app also tracks the food intake, exercise, sleeping time, sleeping hours etc.

Internet of Things (IoT) for Meditation Nowadays, mental health is very important aspect of our real life, due to a busy life, excessive workload and hectic schedule result in mental stress and mental illness. In the field of Internet of things (IoT) [20] meditation app becomes more important in our daily life by reducing our stress by providing peace of mind. Headspace application is a software which is designed in such a manner which provide guided meditations provide SMS alerts, time to chill out and many other functions.

Internet of Things (IoT) for Physicians Physicians can easily track the current situation of a patient using wearable and other devices embedded with Internet of things (IoT) [21]. Doctors are helped by Internet of things (IoT) in healthcare as doctors can identify best suited treatment for the patients.

Internet of Things (IoT) in Hospitals In case of an emergency, the doctor can immediately check the patient's situation and can communicate easily with mobile apps. Patient care is improved by Internet of things (IoT). Internet of things (IoT) [22, 23] devices provides accurate data of a patient and support some features such as monitoring, tracking and real-time alerting. As the Internet of things (IoT) devices help the doctors to get the analysis of the patient's health it also helps [5] the hospitals to keep real time tracking of the various equipment's such as Wheelchairs, Oxygen Pumps, defibrillators, nebulizers and much more. Internet of things (IoT) Devices is Hospitals also helps to manage the assets like pharmacy [24], Health monitoring, Doctor Connectivity, patient monitoring etc.

Internet of Things (IoT) for Hospital Information System Such types of devices are used to collect the information regarding services available in the hospital like number of vacant beds, number of reserved beds, number of patients admitted [25], number of doctors on duty, available emergency services, availability of ambulance service, doctor on call service, doctors appointment, OPD timing, charges of OPD etc.

5 Merits of Internet of Things (IoT) in Healthcare

- Using Internet of things (IoT) reduces data wastage by giving reliable and accurate data with less percentage of error in expensive imaging, mapping and [26, 27] testing which also in one way save cost and resources.
- Continuous monitoring of patients is possible with the help of the Internet of things (IoT) which enables real-time diagnosis and reporting of diseases before it spreads [28] further.
- Internet of things (IoT) promotes research in the healthcare sector because it can effectively collect colossal data about a single case or type of patients, which would otherwise be both difficult and costly if collected in person [29, 30].
- Internet of things (IoT) also helps the large scale policy makers and government decisions by collecting real time data about urbanization, pollution, population, market trends, shopping behaviors etc. [31].
- Internet of things (IoT) technology has the potential to change everything which involves user interaction and generates data for improvements in business, innovations, goal-setting and efficient working of a system [32, 33].

6 Demerits of Internet of Things (IoT) in Healthcare

- Using Internet of things (IoT) for collecting data to help reduce wastage such as testing and expensive imaging and reliable and accurate data gives us less error [34, 35].
- Internet of things (IoT) enables continuously monitor patients, which provide real time data that helps in diagnosis the diseases before it spreads [36].
- Internet of things (IoT) for healthcare can help in research work also as Internet of things enable us to collect massive amounts of data [37, 38] which if collected by a person could cost more.
- As the population is increasing, pollution is also increasing to control the pollution we need real time data and air pattern which is collected by using Internet of things (IoT) device. This helps the policy makers to take decisions and make cities healthier.

7 Conclusion

In this paper, we have reviewed Internet of things (IoT) in healthcare along with Microsoft and Google cloud platform, These are the two big technological [39] competitors, both are there in the market for ages since the introduction of cloud based services now days, till date the competition have reach to the next level. The use of the Internet of things (IoT) with cloud based platform has various domains. All Apps are using cloud based services. One of the domains we covered in this paper is Healthcare. Healthcare is a serious and complex task. Despite 24 h of patients, monitoring doctor is unable to find out the exact medical issue and sometimes in emergency situation doctors couldn't be alerted on time. At this point Internet of things (IoT) [40] comes in the race and fulfills the needs of doctors. Internet of things (IoT) has launched various wearable devices like Hearable which is like a miracle for those who suffer from hearing problems, monitoring machine, smart watches for depression, ingestible sensors and heart rate monitoring. All the Internet of things (IoT) devices are reliable and [38] help us to get medical condition for every minute and whole day long and these devices automatically notify the doctor about the condition and emergency situation. The most common Internet of things (IoT) technology in health care is patient monitors, energy meters and x-rays and imaging devices. Internet of things (IoT) collects accurate data [41], decreases costs as there is no need for visiting doctors, Offer 24 h service at home. However Internet of things (IoT) enter with some issues. Security is a major issue as sensitive information is shared; data is stored in huge amount, human errors are also determined [39]. According to some prediction till the end of 2020, 90% of the hospitals and organization will implement Internet of things (IoT). So the future of the Internet of things (IoT) is bright and will improve and will implement more devices. We have talked about the Amazon cloud architecture and services provided by both Google

and Microsoft, Google is open source [42], provide discount and customer friendly contracts, less data centers while Microsoft can integrate with office tools with a broad feature set, supports [43] hybrid cloud, more data centers etc. As this paper differentiate and review about same technology provided by two different companies along with differences, compatibility and customer demand.

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